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PHYTOPLANKTON COMMUNITIES OF A FLOODPLAIN LAKE OF THE BRAHMAPUTRA RIVER BASIN, UPPER ASSAM

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ABSTRACT

Phytoplankton (52 species; Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae = Dinophyceae) of Samuajan beel, a tropical floodplain lake, registered identical mean annual richness (30 ± 4 species) in littoral and limnetic regions and depicted 33.3 - 77.2 % and 31.4 - 81.1 % community similarities respectively. Their abundance ranged between 137 ± 54 n/l in littoral (Bacillariophyceae > Chlorophyceae) and 122 ± 45 n/l (Chlorophyceae > Bacillariophyceae) in limnetic communities, comprised about 46% of net plankton and indicated winter peaks. This study depicted moderate species diversity, high evenness and low dominance of phytoplankton; species diversity showed significant direct correlation with richness and evenness and an inverse relationship with dominance. Phytoplankton showed significant positive relationship with transparency and silicate and negative with water temperature, rainfall, chloride and nitrate. Multiple regression revealed that ten abiotic factors accounted for > 80 - 98% of density variations of phytoplankton and the dominant groups. ANOVA depicted trends of significance in abundance of the biotic communities analysed.

Keywords: Phytoplankton, floodplain lake, Brahmaputra basin, abundance, ecology

INTRODUCTION

Floodplain lakes or 'beels' constitute important inland aquatic resources of North-eastern India in general and the Brahmaputra and Barak river basins of the state of Assam in particular (Sharma and Sharma, 2001). However, little is known about abundance and ecology of phytoplankton and their role in biological productivity in these environs of India (Jana, 1998). The earlier works from North-eastern region are confined to limited contributions from Assam (Yadava *et al.*, 1987; Dutta *et al.*, 1995; Baruah and Das, 1997, 2001 and Goswami and Goswami, 2001) based on inadequate analysis of plankton. The present study is, thus, of special ecological importance and deals with temporal variations of phytoplankton of a floodplain lake of the Brahmaputra river basin in upper Assam, with remarks on composition, species richness, community similarities, abundance, species diversity, dominance and evenness and on correlations between abiotic and biotic factors.

MATERIAL AND METHODS

The observations were undertaken (March, 1996 - February, 1997) in Samuajan beel (Long.: 94^0 $56'$ E; Lat.: $26^075'$ N) located in the Dhemaji district, Upper Assam. This ox-bow lake (area: 54 ha; depth: 0.7-2.4 m) exhibited luxuriant growth of *Eichhornia crassipes, Azolla pinnata, Lemna minor, Trapa natans, Hydrilla verticellata, Nymphoides indicus,* and *Nymphaea* sp. particularly in the littoral margin. The fish fauna of this beel included *Labeo rohita, L. gonius, Cirrhinus mrigala, Catla catla, Notopterus chitala, Nemacheilus botia, Mystus vittatus, Bagarius bagarius, Ompok bimaculatus, Puntius ticto and Heteropneustes fossilis.*

Water samples were collected from two sampling stations, one each located in the littoral and limnetic regions, of Samuajan beel at regular monthly intervals and were analysed for various abiotic factors following APHA (1992). The monthly qualitative and quantitative plankton samples were obtained from the two sampling stations by a nylobolt plankton net (No.25) and were preserved in 5% formalin. The former, collected by towing a plankton net, were examined for qualitative analysis and various phytoplankton taxa were identified following the works of Needham and Needham (1962), Islam and Haroon (1980), Adoni *et al.,* (1985) and Fitter and Manuel (1986). Quantitative plankton samples, each collected by filtering 25 litres of lake water, were analysed for abundance of phytoplankton and their constituent groups. Community similarity (Sorensen's index), diversity (Menhinick and Shannon's indices), dominance (Berger-Parker's index) and evenness (E1 index) were calculated following Ludwig and Reynolds (1988) and Magurran (1988). The correlation coefficients (r_1 and r_2) and multiple regressions ($R^2{}_1$ and $R^2{}_2$) were computed between abiotic and biotic factors separately for limnetic and littoral regions respectively. ANOVA was applied to analyse significance of temporal variations in abundance of the planktonic communities studied.

RESULTS AND DISCUSSION

Annual variations (mean $\pm$ S.D.) of abiotic factors (Table 1) affirmed tropical nature of Samuajan beel concurrent with its geographical location, low transparency, low electrolyte concentration, slightly acidic to slightly alkaline hard-waters with Ca> Na > Mg > K, unsaturated dissolved oxygen content, low chloride indicating lack of organic pollution and low micro-nutrient concentrations. Temporal variations of abiotic factors of this floodplain lake were discussed earlier by Sharma and Hussain (1999).

Net plankton density registered significant variations during different months ($F_{11,11}$ = 3.5303, P<0.02), and insignificant between two regions, followed different trends of monthly variations in limnetic (253 $\pm$ 132 n/l) and littoral (317 $\pm$ 110 n/l) regions and registered winter peaks. The recorded abundance broadly corresponds with the results of Lahon

Table 1: Annual variations in Abiotic Factors

Factors	Range	Mean $\pm$ S.D.
Water temperture (°C)	17.0 - 31.0	24.4 $\pm$ 4.7
Transparency (cm)	12.0 - 84.0	50.0 $\pm$ 28.2
Specific conductivity (µS/cm)	70.0 - 186.0	125.6 $\pm$ 37.2
pH	6.5 - 7.5	6.8 $\pm$ 0.4
Dissolved oxygen (mg/l)	4.0 - 11.2	6.8 $\pm$ 3.2
Free carbon dioxide (mg/l)	4.0 - 8.0	5.6 $\pm$ 1.4
Total alkalinity (mg/l)	36.0 - 100.0	66.3 $\pm$ 23.3
Hardness (mg/l)	48.0 - 120.0	82.5 $\pm$ 23.1
Calcium (mg/l)	23.0 - 54.6	42.8 $\pm$ 11.2
Sodium (mg/l)	12.0 - 40.0	25.1 $\pm$ 9.5
Magnesium (mg/l)	6.0 - 16.4	9.6 $\pm$ 3.2
Potassium (mg/l)	2.0 - 7.0	3.0 $\pm$ 1.6
Chloride (mg/l)	7.8 - 15.6	12.0 $\pm$ 2.9
Sulphate (mg/l)	4.2 - 33.4	14.9 $\pm$ 9.9
Nitrate (mg/l)	1.2 - 1.8	1.5 $\pm$ 0.20
Phosphate (mg/l)	0.01 - 0.29	0.09 $\pm$ 0.1

(1983) but is lower than the reports from other beels of Assam (Goswami, 1985; Yadava *et al.*, 1987) and elsewhere in India (Rai and Dutta-Munshi, 1982; Sugunan, 1989; Vass, 1989; Baruah *et al.*, 1993; Sinha *et al.*, 1994). Further, they showed significant positive correlation with transparency (r_1 = 0.580; r_2 = 0.508) and pH (r_1 = 0.573) and an inverse relationship with chloride (r_1 = -0.671; r_2 = -0.718).

Phytoplankton showed moderate richness with Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae = Dinophyceae indicating 28, 15, 5, 2 and 2 species respectively. Overall richness agrees with the reports by Acharjee *et al.*, (1995) and Sanjer and Sharma (1995) but is higher than that of Goswami and Goswami (2001) and Patil (2002). Species richness, however, did not register any definite seasonal or monthly pattern (Fig 1) except lower numbers in certain monsoon months. Littoral (52 species) and limnetic (49 species) phytoplankton depicted identical mean annual values (30 $\pm$ 4) species); they recorded similarity between 33.3-77.2% and 31.4-81.1% respectively, with 50-70% similarity in 66.7% cases included in respective similarity matrices.

ANOVA depicted significant phytoplankton density differences between months ($F_{11, 11}$ = 0.3899, $P<0.05$) and an insignificant difference between (157 $\pm$ 54 n/l) and limnetic (122 $\pm$ 45 n/l) communities and contributed significantly (46%) to net plankton (r_1 = 0.799; r_2 = 0.573). This feature is in contrast to phytoplankton predominance reported from the floodplain lakes from different parts of India i.e., Kashmir (Kaul and Pandit, 1982), Bihar (Rai and Dutta - Munshi, 1982; Baruah *et al.*, 1993 Sanjer and Sharma, 1995), West Bengal (Sugunan, 1989), Rajasthan (Vyas, 1989) and Assam (Yadava *et al.,* 1987; Baruah and Das, 1997, 2001; Goswami & Goswami, 2001), Kerala (Krishnan *et al.,* 1999) and Maharashtra (Patil 2002). This study depicted broadly multimodal pattern (Fig. 2 & 3) of phytoplankton abundance, with primary maxima during spring / summer (March / April), two monsoon maxima (June and August) and peak during winter (December). This is in contrast to bimodal pattern noticed by Lahon (1983), Goswami (1985), Yadava *et al.,* (1987) and Sanjer and Sharma (1995) but agrees with the stated workers with reference to summer and winter maxima. However, phytoplankton showed relatively little density variations during March - June (except in May) and indicated marginal decline during September - November. The present study registered positive correlations between phytoplankton vs. transparency (r_1 = 0.490, r_2 = 0.475) and silicate (r_2 = 0.495) and inverse relationship with water temperature r_1 = -0.701, r_2 = –0.609), rainfall (r_2 = -0.559), chloride (r_1 = –0.650, r_2 = –0.648) and nitrate (r_1 = –0.591, r_2 = –0.589). In addition phytoplankton recorded positive correlation with zooplankton only in limnetic region (r_1 = 0.494), which in turn, corresponds with the results of Vasisth and Sharma (1975), Goswami (1985) and Yadava *et al.,* (1987). In fact, their winter peak coincided with maxima of the latter while two communities followed inverse patterns during the first half of the study period.

The Chlorophyceae and Bacillariophyceae are dominant quantitative groups of phytoplankton (Table 2) and followed patterns of monthly

Table 2: Annual variations in Plankton communities

Factors	LIMNETIC Range (Mean ± S.D.)	LITTORAL Range (Mean ± S.D.)
NET PLANKTON (n/l)	141 - 463 (253 ± 132)	174 - 475 (317 ± 110)
PHYTOPLANKTON		
Qualitative : Bacillariophyceae > Cyanophyceae > Euglenophyceae = Dinophyceae		
Species richness (total)	49 species	52 species
Species richness (monthly)	24 - 36 (30 ± 4) Species	25 - 39 (30 ± 4) species
Community similarity (%)	31.4 - 81.1	33.3 - 77.2
Quantitative:	Chlorophyceae>Bacillariophyceae > Cyanophyceae>Dinophyceae > Euglenophyceae	Bacillariophyceae>Chlorophyceae >Cyanophyceae>Dinophyceae > Euglenophyceae
Abundance (n/l)	78 - 226 (122 ± 45)	70 - 273 (137 ± 54)
Percentage	25.3 - 70.0 (46.5 ± 12.1)	21.2 - 71.8 (46.1 ± 15.2)
Chlorophyceae (n/l)	26 - 121 (57 ± 26)	24 - 114 (55 ± 29)
Percentage	28.0 - 61.2 (45.7 ± 9.9)	16.4 - 62.5 (39.6 ± 10.8)
Bacillariophyceae (n/l)	33 - 88 (51 ± 18)	35 - 129 (66 ± 23)
Percentage	31.4 - 59.0 (43.1 ± 91.)	28.2 - 67.1 (49.6 ± 8.8)
Cyanophyceae (n/l)	3 - 18 (8 ± 5)	1 - 24 (8 ± 6)
Percentage	2.2 - 10.6 (6.3 ± 2.9)	0.8 - 12.9 (5.8 ± 3.2)
Dinophyceae (n/l)	1 - 12 (4 ± 3)	1 - 12 (5 ± 4)
Percentage	0.9 - 8.5 (3.2 ± 2.4)	0.8 - 8.1 (3.9 ± 2.7)
Euglenophyceae (n/l)	1 - 9 (2 ± 2)	1 - 12 (2 ± 3)
Percentage	0.4 - 6.3 (2.2 ± 2.1)	0.8 - 7.9 (2.0 ± 2.3)

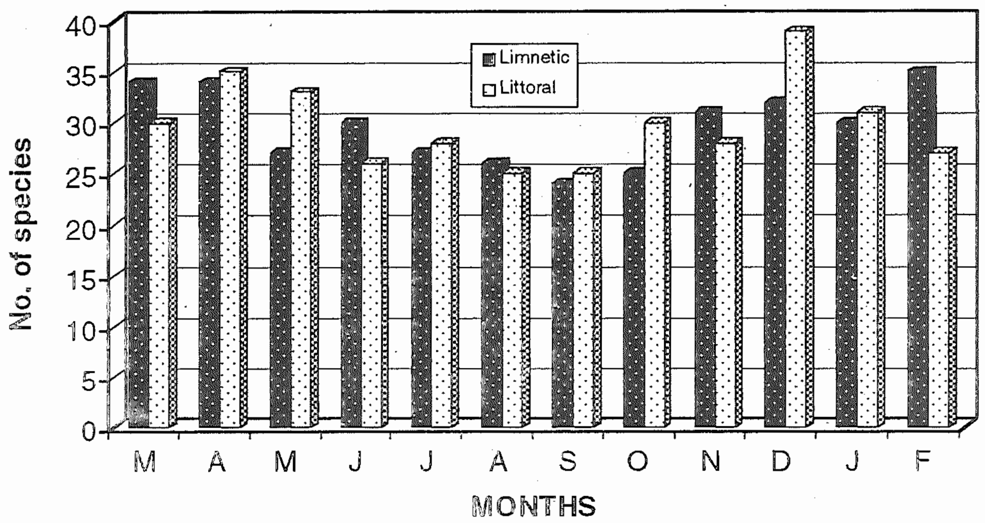

Fig.1 : Temporal variations in Phytoplankton species richness

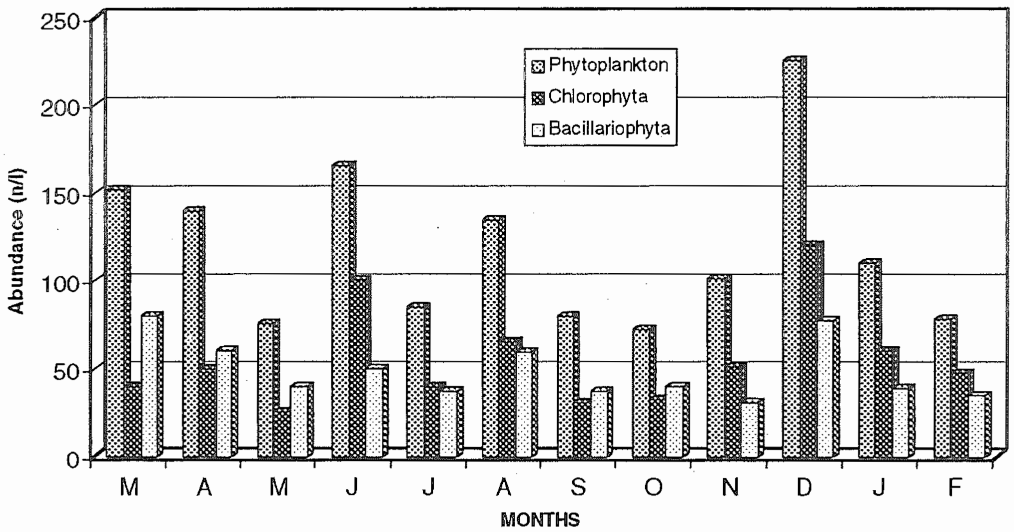

Fig.2 : Temporal variations of Phytoplankton and dominant (Limnetic region)

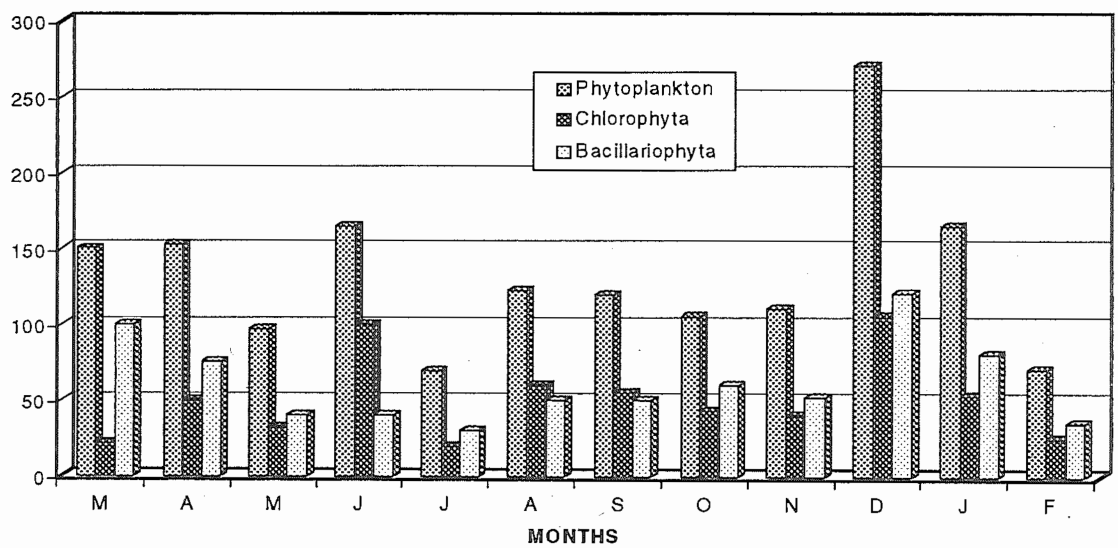

Fig.3 : Temporal variations of Phytoplankton and dominant groups (Littoral region)

variations (Figs. 2 & 3) concurrent with that of total phytoplankton. Green algae predominated over the diatoms in limnetic communities while the reverse pattern was seen in littoral region. Bacillariophyceae > Chlorophyceae and Chlorophyceae > Bacillariophyceae contributed to phytoplankton spring / summer maxima and monsoon maxima respectively; the green algae are dominant in limnetic and the diatoms in littoral communities during their winter peaks. Higher abundance of the Chlorophyceae concur with the reports of Goswami (1985), Yadava *et al.*, (1987), Choudhary and Singh (2001), Goswami and Goswami (2001) while that of the diatoms agrees with the works of Baruah *et al.*, (1993) and Krishnan *et al.*, (1999). The green algae made important contributions to abundance of net plankton ($r_1 = 0.604$, $r_2 = 0.456$) and phytoplankton ($r_1 = 0.838$, $r_2 = 0.811$). Besides, the diatoms contributed significantly to net plankton ($r_1 = 0.753$, $r_2 = 0.465$) and phytoplankton ($r_1 = 0.801$, $r_2 = 0.871$) in limnetic and littoral communities but recorded a significant correlation with the green algae only in the latter region ($r_2 = 0.687$).

ANOVA indicated significant density differences of the Chlorophyceae between linnetic and littoral regions ($F_{1.11} = 2.362$, $P < 0.05$) but was insignificant between months. In contrast, Bacillariophyceae registered significant density variations between months ($F_{11.11} = 6.867$, $P < 0.02$) as well as between two regions ($F_{1.11} = 4.531$, $P < 0.005$). The green algae showed significant correlation only with silicate ($r_1 = 0.505$) in limnetic region but registered no significant relationship with any of the abiotic factors in littoral region. Limnetic diatom communities indicated significant correlations with specific conductivity ($r_1 = 0.0511$), pH ($r_1 = 0.522$), transparency ($r_1 = 0.534$), chloride ($r_1 = -0.512$) and nitrate ($r_1 = -0.543$) while littoral diatoms showed significant relationships with fourteen abiotic parameters namely rainfall ($r_2 = -0.630$), water temperature ($r_2 = -0.744$), specific conductivity ($r_2 = 0.667$), pH ($r_2 = 0.517$), transparency ($r_2 = 0.522$), alkalinity ($r_2 = 0.571$), hardness ($r_2 = 0.596$), Calcium ($r_2 = 0.580$), Magnesium ($r_2 = 0.538$), Potassium ($r_2 = 0.524$), chloride ($r_2 = -0718$), phosphate ($r_2 = -0.448$), nitrate ($r_2 = -0.669$) and silicate ($r_2 = 0.491$).

The other constituents namely Cyanophyceae > Dinophyceae > Euglenophyceae followed the mentioned order of quantitative importance, recorded very low densities and comprised only between 2.0 - 6.3% of limnetic and littoral phytoplankton; the last two groups were not observed in all monthly collections. The first and last group showed maximum abundance during winter in both communities while Dinophyceae indicated highest density during April and December respectively.

In general, individual phytoplankton taxa do not show any periodicity of temporal variations. Various important green algae included Dictyosphaerium sp. (1-62 n/l), *Actinastrum* sp. (1-35 n/l), *Gonium* sp. (1-30 n/l), *Spirogyra crassa* (1-30 n/l), *Volvox* (1-32 n/l), *Ulothrix cylindricum* (1-16 n/l). The notable diatoms are *Achnanthes lanceolata* (5-40 n/l), *Navicula radiosa* (2-30 n/l), *Stauroneis* sp. (2-25 n/l), Gyrosigma attenuatum (2-15 n/l), Diatoma sp. (3-10) while *Anabaena cylindrica* (1-10) is the sole blue-green alga.

Shannon's index reflected moderate species diversity of limnetic (2.979 ± 0.210) and littoral (2.881 ± 0.241) phytoplankton and followed no particular periodicity; maximum and minimum diversity was noticed during winter (February) and monsoon (August) in the former and during summer (May) and monsoon (June) in the latter region respectively. It showed significant positive relationships with richness (r_1 = 0.584, r_2 = 0.517) and evenness (r_1 = 0.851, r_2 = 894) and negative with density (r_1 = -0.851, r_2 = –0.864). Menhinick's index also registered broadly identical values of mean diversity (2.797 ± 0.435, 2.636 ± 0.404) of two communities without any definite pattern and showed direct correlations with evenness (r_1 = 0.764, r_2 = 0.884) and inverse correlations with density (r_1 = -0.656, r_2 = 0.630) and dominance (r_1 = -0.513, r_2 = -739). The present study registered low dominance (0.188 ± 0.067) and high evenness (0.878 ± 0.051); the former recorded significant negative relationship with the latter (r_1 = -0.659, r_2 = -0.655). Phytoplankton of Samuajan beel indicated higher diversity, nearly identical dominance and lower evenness than that reported from Dighali beel of Assam (Acharjee *et al.,* 1995). In general, composition and abundance of phytoplankton and their moderate species diversity affirm mesotrophic character of Samuajan beel; this generalization confirms earlier remarks by Sharma and Hussain (2001).

Multiple regression of ten abiotic factors namely rainfall, water temperature, transparency, specific conductivity, pH, free CO_2, dissolved oxygen, alkalinity, hardness and chloride with phytoplankton (R^2_1 = 0.9471, R^2_2 = 0.8099), Chlorophyceae (R^2_1 = 0.8167, R^2_2 = 0.9144) and Bacillariophyceae (R^2_1 = 0.9431, R^2_2 = 0.9872) exhibited significant cumulative impact (> 80 - 98 %) on abundance of the mentioned limnetic and littoral communities. In addition, they accounted for variable component i.e., btween 76 - 97% of densities of net plankton (R^2_1 = 0.7651, R^2_2 = 0.9730) of two communities.

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